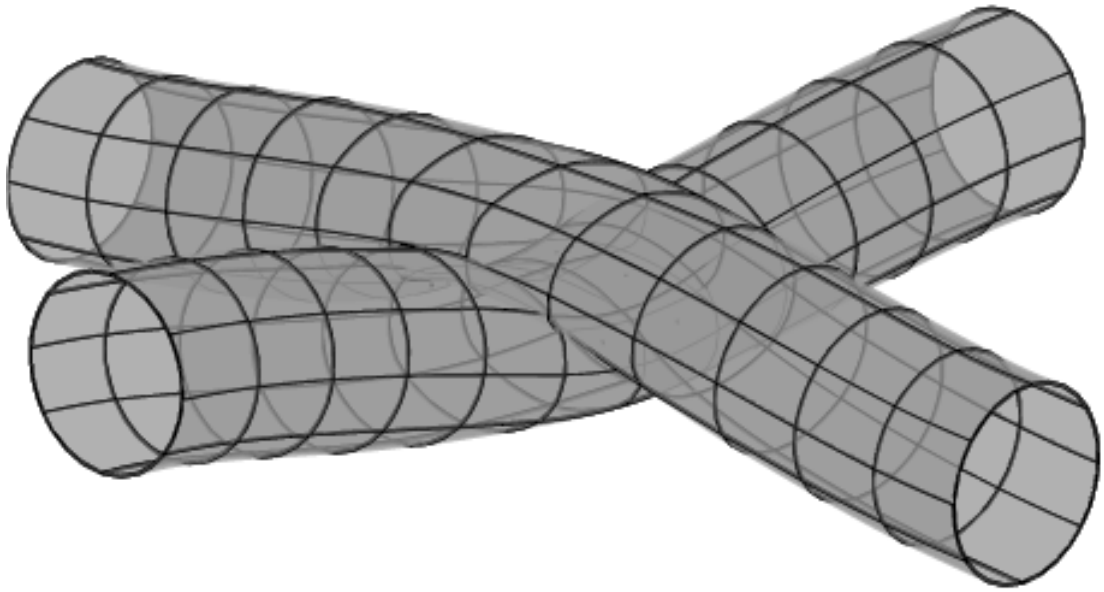
Baustatik und Baudynamik

Master Thesis

Explanation regarding LaTeX Template for Bachelor and Master Theses

Jane Q. Citizen



submitted at the

University of Stuttgart
Germany

Institute for Structural Mechanics
Prof. Dr.-Ing. habil. Manfred Bischoff

Explanation regarding LaTeXTemplate for Bachelor and Master Theses

by

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in the study program

Computational Mechanics of Materials and Structures, COMMAS (M.Sc.)

under the supervision of

John Q. Public, M.Sc.

Declaration

- Hiermit erkläre ich, dass ich die hier vorliegende Master Thesis selbstständig verfasst habe.
- Es wurden nur die in der Arbeit ausdrücklich benannten Quellen und Hilfsmittel verwendet. Wörtlich oder sinngemäß übernommenes Gedankengut habe ich als solches gekennzeichnet.
- Die eingereichte Arbeit war und ist weder vollständig noch in wesentlichen Teilen Gegenstand eines anderen Prüfungsverfahrens.
- Ebenso habe ich die Arbeit weder vollständig noch in Teilen bereits veröffentlicht.
- Ich versichere, dass das elektronische Exemplar mit den anderen Exemplaren übereinstimmt.

Stuttgart, June 23, 2021 _____

Baustatik und Baudynamik

Universität Stuttgart

Institut für Baustatik
und Baudynamik

Prof. Dr.-Ing. habil. M. Bischoff

Master-/ Diplomarbeit

Implementierung und Vergleich von Kontaktsuchalgorithmen

In der Strukturmechanik wird von Kontakt gesprochen, wenn mehrerer Körper aufeinander treffen und Kräfte oder auch Temperaturen durch Kontakt von einem Körper auf den anderen übertragen werden. Kontaktprobleme spielen in vielen Bereichen des Maschinenbaus sowie des Bauingenieurwesens eine wichtige Rolle, beispielsweise in Crashtest- und Umformsimulationen. Zur numerischen Simulation dieser Probleme werden stabile Kontaktalgorithmen benötigt.

Die Kontaktsuche hat zur Aufgabe die Ränder der Körper zu bestimmen, die so nahe beieinander liegen, dass Sie möglicherweise in Kontakt kommen könnten. Das hat den Vorteil, dass die rechenintensive Abstandsberechnung zwischen den Körpern nur entlang der durch die Kontaktsuche ermittelten Ränder erfolgen muss.

Für effiziente Kontaktsuchalgorithmen gibt es verschiedene Ansätze, die in dieser Arbeit untersucht und verglichen werden sollen. Außerdem soll eine neue Herangehensweise überprüft werden, die den Raum zwischen den möglichen Kontaktkörpern diskretisiert und mithilfe eines Netzbewegungsalgorithmus´ Aufschluss über mögliche Kontaktgebiete geben soll.

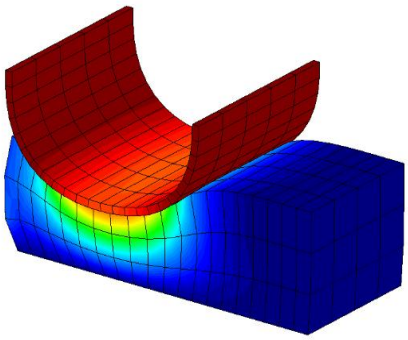


Abb. 1: Dreidimensionales Kontaktbeispiel

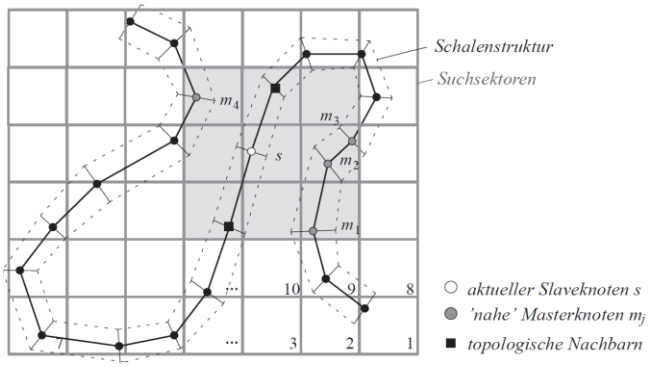


Abb. 2: Bucket-Sort Algorithmus (zweidimensionale Darstellung) [Gee, 2004]

Im Einzelnen:

- Einarbeitung in das Thema Kontaktmechanik und Kontaktsuche,
- Implementierung verschiedener Algorithmen (Bucket-Sort Algorithmus, Bounding Volume Hierarchy),
- Implementierung eines Suchalgorithmus´ basierend auf einem Hilfsnetz, welches den Raum zwischen den möglichen Kontaktkörpern diskretisiert,
- Vergleich der einzelnen Kontaktsuchalgorithmen.

Ansprechpartner: Malte von Scheven (Raum 1.005)

Abstract

Here should be a short summary of the subject of the thesis. The reader should get an overview of the subject and the methods you use. The abstract should not exceed half a page.

Preface

At this point you can write an expression of thanks if you like to. It's optional.

Stuttgart, in October 2014 Jane Q. Citizen

Contents

1

Installation

In this chapter the installation for the recommended programs are shown. All presented programs are freeware. There respective homepages are also indicated. At first the installation of the drawing program Inkscape is explained and then the program MiKTeX, which is the foundation for LaTeX. Afterwards the PDF-Reader Sumatra PDF will be installed. For drawing mathematically functions and illustrating data sets, the program gnuplot will be installed. Finally Ecplipse and the additional program TeXlipse as a text editor for LaTeX will be installed. At the end you need to apply the settings from chapter 1.2.

1.1 Programs

The following installation process is explained for the operating system Windows 7. For other operating systems the installation process can be different. Every student is responsible for oneself to install the programs. The Institute for Structural Mechanics is without responsibility for any damage due to the installation progress or the programs.

1.1.1 Inkscape

Inkscape is a multi-platform program to create and to edit 2-dimensional vector graphics. The installation is very easy.

- Download current .exe-Installer (http://inkscape.org/download/?lang=de)
- Install the program with the standard settings

1.1.2 MiKTeX

MikTex is a TeX distribution, that means a compilation of software which are used for LaTeX.

- Download current version (http://miktex.org/download)
- Right Mouse click on the downloaded file *basic-miktex-2.9.????.exe* → run the exe.file
- Do you want to allow. . . → **Yes**
- [x] I accept the MiKTeX copying conditions → **Continue**
- [o] Anyone who uses this computer (all users) → **Continue**
- → **Continue**
- Preferred paper: A4
- Install missing packages on-the-fly: Yes → **Continue**
- → **Start** (wait. . .)
- → **Continue**
- → **Close**

Change Repository

- Start → All Programs → MikTeX 2.9 → Maintenance (Admin) → Package Manager (Admin)
- Repository → Change Package Repository
- [x] Package shall be installed from the Internet
- → **Continue**
- Choose Germany Uni Hannover
- → **Finish**
- Close Package Manager

1.1.3 Sumatra PDF

As a PDF-Reader we recommend Sumatra PDF. The advantage of this program over Adobe Reader is, that it is for free and it can easily be connected to Eclipse. Also you can leaf the PDF file open during the translation progress.

- Download current .exe-Installer
  `https://www.sumatrapdfreader.org/download-free-pdf-viewer`
- Install the program with the standard settings

1.1.4 Gnuplot

Gnuplot is a graphic program for mathematical functions and numeric entities. It can directly be opened in Eclipse so you don't need to run it extra.

- Download current .exe-Installer
  `http://sourceforge.net/projects/gnuplot/files/`
- Install the program with the standard settings

1.1.5 Sublime Text

Sublime Text is a simple but expandable text editor, which can be used to build and edit LaTeXfiles.

- Download current version (`https://www.sublimetext.com/3`)
- → Choose 64 bit Installer
- → Install

Furthermore the following programs are needed:

Perl

- Download current version (`http://strawberryperl.com/`)
- → Install

ImageMagick

- Download current version (`http://www.imagemagick.org/script/download.php#windows`) (Win64 dynamic at 16 bits-per-pixel)
- Make sure during installation that the option `Add application directory to your system path` is checked.
- → Install

I

Ghostscript

- Download current version (`https://www.ghostscript.com/download/gsdnld.html`) (Ghostscript X.XX for Windows (64 bit), Ghostscript AGPL Release)
- → Install

1.1.6 Files from IBB

In ILIAS two zip archives are available gestellt:

- **IBB_Abschlussarbeit.zip**: contains the workspace with the actual template for the thesis
- **IBB_Thesis_styles.zip**: contains configuration files for LaTeXand Eclipse
- **SublimePackageFolder.zip**: contains the required configuration files to easily use Sublime Text as LaTeXeditor

Copy all zip archives to your local computer and extract them.

1.2 Settings

1.2.1 Set the System variable

The required system variables need to be defined to allow the simple interaction between the installed programs.

- → **Win + pause** → advanced settings → system variables
- The following directories have to be **added** to the system variable `PATH` , if they do not exist. These path can change between version. Therefore, first check if the following directories exist and otherwise modify them accordingly.

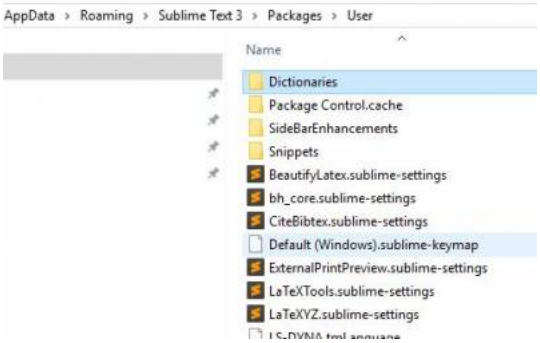
  - `C:\Program Files\gnuplot\bin`
  - `C:\Program Files\Inkscape\bin`
  - `C:\Program Files\Sublime Text 3`
  - `C:\Program Files\gs\gs9.10\bin`

  Depending on your installation the files can also be in `C:\Program Files (x86)\`. Please check, if these paths are correct.

- Additonally, Latex needs to know where to find the IBB-style files of the file **IBB_Thesis_styles.zip**.
- Thus, we need to define the system variable `TEXINPUTS` as the path where the extracted files of **IBB_Thesis_styles.zip** are located. For example `D:\vorlagen\LaTeX\styles`. If this system variable does not exist just add it as a new variable.

1.2.2 Sublime Text

- Open Sublime Text
- **Ctrl+Shift+P** → "install Package Control" → wait..
- TopBar Menu → Preferences → Browse Packages. This should open a folder in Windows Explorer. Here navigate into the User Folder
- Close SublimeText
- Insert the content of the file **SublimePackageFolder.zip** into the previously opened User Folder.
- This should now look similar to



- At the end start Sublime Text again and wait until all packages are installed.

1.2.3 Setup Sumatra PDF

- First open a project `IBB_Abschlussarbeit.sublime-project`
- Open the `Abschlussarbeit.tex` files
- Build it with **Ctrl+b**. If no errors occur Sumatra PDF should open automatically.
- **Settings** → **Options** → Command line for inverse search
- Insert `"C:\Program Files\Sublime Text 3\sublime_text.exe" "%f:%l"` (with all quotes!). If Sublime Text is installed somewhere else modify it accordingly.

The installation is now complete. In the next chapter it is explained how to use the new installed programs.

2

Operating the software

The following descriptions for operating the recommended programs only contain basic commands. Further information you can get by using the help menu of the program or by searching the Internet.

2.1 Inkscape

As mentioned earlier, Inkscape is a graphic tool for creating vector graphics. You can also paste and edit normal pictures. The advantage of the program is the combination between Inkscape and the LaTeX-template from the institute. You can easily include your Inkscape graphics and every text will be translated to the LaTeXstyle.

2.1.1 The most important commands

The now following commands are all key combinations which will help you to work faster. You can do every command also by pointing and clicking with your mouse.

Drawing a line

1. Press **Shift+F6**
2. Click for a start and an end point
3. You can add more lines or you can finish your input with right mouse click

Choose an object

1. Press **F1**
2. Select an object

Edit an object

1. Select an object
2. Press **Shift+Ctrl+F**
3. Edit your object (muster and shape of the line,filling, etc.)

Align object

1. Select an object
2. Press **Shift+Ctrl+A**
3. Select desired orientation

Edit single nodes from an object

1. Press **F2**
2. Select an object
3. Select and edit a node

Hint: Nodes can also be aligned with each other (e.g. they can be adjust on the same height). Therefore you have to hold the Shift button while you select the nodes. After that, you can open the wizard for orientation and orientate your selected nodes as you want to.

Paste a text

1. Press **F8**
2. Write a text. If you want to write a formula you have to enter it like in LaTeX, e.g. `$\alpha$`, height and font are declared by LaTeX.

Save a graphic

1. Save as .svg file. (in the directory of LaTeX-folder of the corresponding chapter).

2.2 Sublime Text & SumatraPDF

2.2.1 Autocomplete

Ctrl+space enables autocomplete. To use it just start typing the corresponding command and Sublime Text will show (if there is more then one) several option. This also works for references as citing.

2.2.2 Spell check

Spell checking can be enabled using **F6** in Sublime Text. Using View-> discretionary -> User several languages are available. If the word is red underlines it is wrong or the discretionary does not know the word. Using right click the word can be added to the dictionary.

2.2.3 Build project

If a `.tex` file is opened the corresponding project can be build using the hotkey **Ctrl+b**. If Sublime Text shows a drop-down menu with LaTex, LaTex Traditional etc. as options stay with the plain "LaTex".

2.3 Gnuplot

By means of the template “Beispielplot.gp” this Chapter will illustrate the basic functions of the program Gnuplot. For example to define the size of the drawing area, to label the axes, to define which curves will be plotted and so on.

During the translation progress, the file “Beispielplot.gp” is automatically building the file “Beispielplot.tex”. These translated commands can now be processed by PDF Latex.

2.3.1 Explanation to the template “Beispielplot.gp”

In the main file “Beispielplot.gp” the most important passages are commented. So the structure of the important commands can be recognized.

```
# define the size of your drawing area
set terminal tikz color size 10cm, 7cm
set output '03_program_introduction/Beispielplot.tex'

# define tour type of axes with a net in the drawing area
set grid
```

```
set xzeroaxis lt -1 linewidth 1
set yzeroaxis lt -1 linewidth 1

# set x-/y-axis
set xrange [0:15.708]
set yrange [-3.2:0.4]

# Division of the axis
set xtics 2
set ytics 0.4

# label of the axis
set xlabel 'Pfad'
set ylabel ' $M_{xx}$'

# Position and height of the key
set pointsize 2.0
set key box
set key bottom right

# Set a annotation into the drawing area
set label "Spitze" at 1.7,-1.8

# define a continuous reference solution
Konstante=1.0
Ref(x)=-cos(x/10.0)*Konstante*Konstante*Konstante

# Plot the graph
plot\
'03_program_introduction/Datenreihe1.data' u 1:2  title 'Daten 1'...
      with points  linecolor rgb "red" pt 4  ps 2 ,\
'03_program_introduction/Datenreihe2.data' u 1:2  title 'Daten 2'...
      with lines  lt 2 lw 2  pt 8  ps 1  linecolor rgb "green",\
Ref(x) title ' Analytisch' with lines  lt 1 lw 2 linecolor rgb "blue"
```

The command "set out" defines where the file will be saved. Here you should always give the relative path from the main file (thesis.tex) to the .tex file which you want to create with gnuplot. The .tex file has to have the same name as the .gp-file.

In the following diagram (Figure 2.1) different plot-styles are shown. Besides the continuous analytic curve "Analytisch" there are 2 other curves based on data sets.

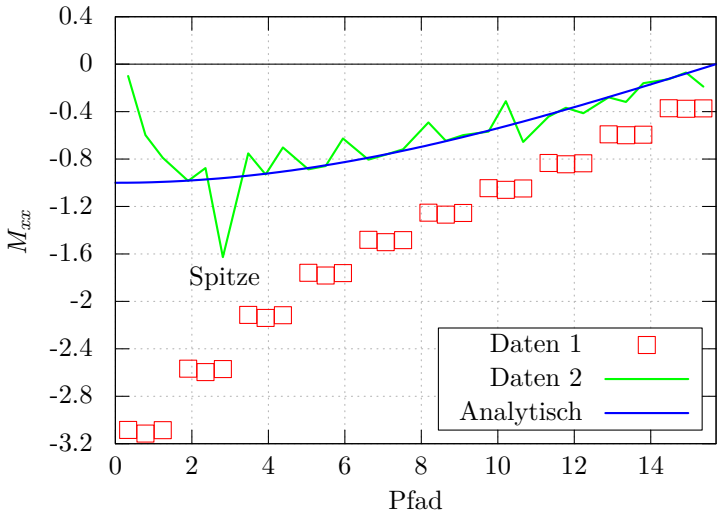


Figure 2.1: Momentenverlauf entlang des Pfades.

curve “Analytisch”

The curve “Analytisch” (German for analytically) describes a continuous cosine function. As shown above the constants can be freely defined and be used in mathematically functions (here: name of the function is “Ref(x)”). After the command “plot” the following line is

```
Ref(x) title 'Analytisch'
 with lines lt 1 lw 2 linecolor rgb 'blue'
```

One by one it defines the curve, the name of the curve, the plot-type, the line type, the line thickness and the color of the lines.

Curves “Daten 1” and “Daten 2”

On the contrary both following curves are based on data sets. These data sets are for example stresses evaluated at certain points. They are stored in the extra files “Datenreihe1.data” and “Datenreihe2.data”. In the following plot commands

```
u 1:2
```

is defined that the first column becomes the x-axis and the second column becomes the y-axis. In Figure 2.1 a point and a line plot is illustrated exemplarily.

Test page

If you open the program Gnuplot and you enter the command “test” it will start the following test page.

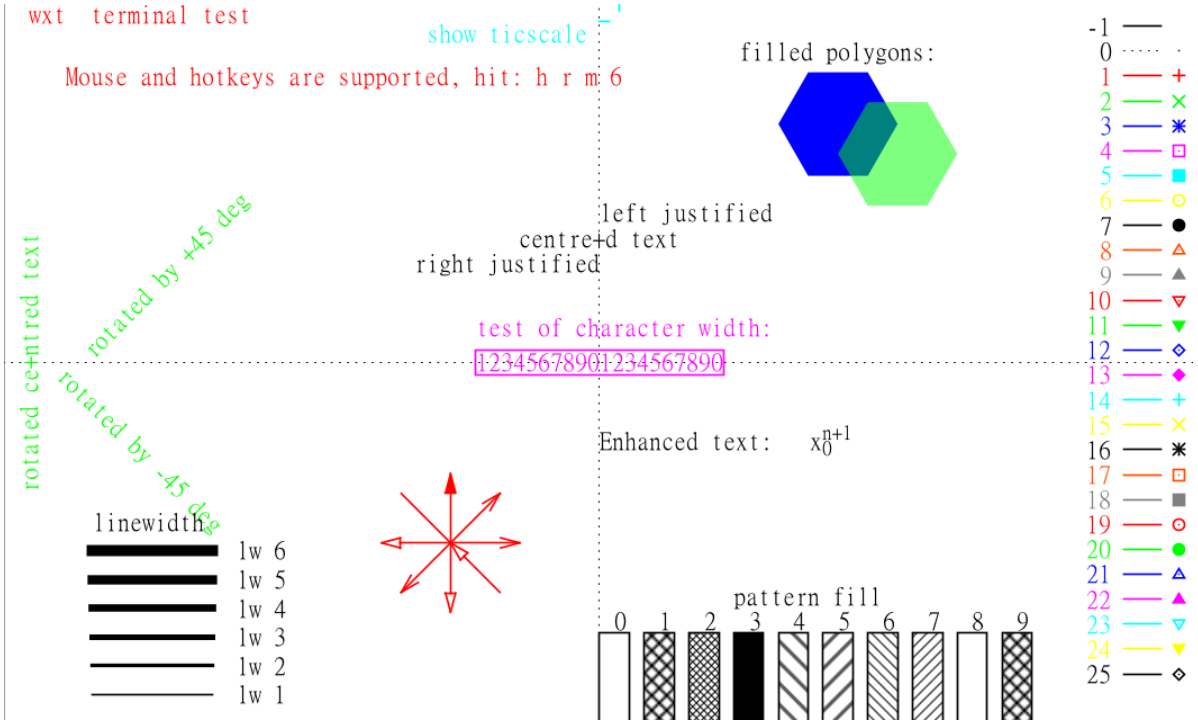


Figure 2.2: Gnuplot- Test page with Information of type of line, color, etc.

From the image you may extract a list of type of lines, colors, symbols and so on.

3

Application of the LaTeX-template

This chapter is about features of the provided template and its use. It will explain how you can write formulas, create tables and insert pictures.

3.1 Options of this template

The documentclass `IBB_thesis` supports four options, each having two possible choices. One has always to give all four options.

```
\documentclass[english,twoside,final,print]{../styles/IBB_thesis}
```

The order is unimportant.

3.1.1 German or English

With the language selection German `ngermen` or English `english` the cover, captions and hyphenation will be switched.

3.1.2 Onesided or two-sided

There is the possibility to change the template depending on the way you want to print your text from `oneside` to `twoside`. This is important, hence you would have same numbered white page for a onesided print which are correctly on the back for a two-sided print.

3.1.3 Draft or final version

With the option `darft` the compilation of the pdf-document can be accelerated (pictures will just be shown as boxes). Furthermore labels will be shown in order to facilitate to reference pictures and equations. For printing the option `final` has to be chosen.

3.1.4 Print or web

With the option `web` references within the document will be generated as a link, therefore one can jump to a certain section by clicking on a caption in the table of contents or from a reference to the proper figure, table or equation.

3.2 General information

At the top of the thesis.tex file you can input general information which are always needed and they will automatically be taken for your cover sheet.

3.3 Create a new chapter

You should create a new folder/directory for every new chapter. In this directory you should save the .tex-file and all graphics and diagrams for this chapter. Afterwards you need to bind the .tex file with your main-file by the command \input. In order to find figures in the new directory, it has to be added to `\graphicspath` in the main-file (thesis.tex) (see also section 3.6).

3.4 Formulas

To better understand the following remarks the pdf and the source code "04_example_chapter.tex" should be viewed simultaneously.

A formula is always expressed as source code. If you want to write, for example, an α, `\alpha` must be specified. A particularly useful website for this purpose is `https://en.wikipedia.org/wiki/Help:Displaying_a_formula`. Here, almost every Greek letter or mathematical formula characters can be found. To make formulas more compact and clearer, one can use the abbreviations for Greek letters, symbols, units ... which are defined by IBB . A summary of all predefined commands can be found in a separate PDF named as "Abkuerzungen.pdf". By using these abbreviations (for example, `\al` instead of `\alpha`) formatting errors may automatically be avoided.

3.4.1 Appearance

Short formulas like $\sigma = \frac{F}{A}$ that are given in sentences, must be enclosed with `$`-symbol. Isolated formulas are defined in an extra enviroment `align` as follows:

$$\mathbf{x} = \boldsymbol{\phi}(\mathbf{X}, t). \tag{3.1}$$

If a paragraph is to be directly adjacent to a formula, no blank line shall be inserted between the formula and the text after or before it. In order to make the source code still clear, the `%`-character can be inserted, which leads to commenting out the line.

If two or more rows are needed in an `align`-enviroment, the line is broken with the command `\\` and the formulas are aligned with the `&`-symbol. As an example here at the first equal sign:

$$\dot{\mathbf{u}}(\mathbf{X}, t) = \frac{\partial \boldsymbol{\phi}(\mathbf{x}, t)}{\partial t} = \frac{\partial \mathbf{u}(\mathbf{x}, t)}{\partial t}, \tag{3.2}$$

$$\ddot{\mathbf{u}}(\mathbf{X}, t) = \frac{\partial \dot{\mathbf{u}}(\mathbf{x}, t)}{\partial t}. \tag{3.3}$$

If several formulas are to be located side by side, more `&`-symbols can be used in order to obtain the desired arrangement.

$$a_{11} = b_{11} \qquad a_{12} = b_{12} \qquad a_{13} = b_{13} \tag{3.4}$$

$$a_{21} = b_{21} \qquad a_{22} = b_{22} + c_{22} \qquad a_{23} = b_{23} \tag{3.5}$$

A special arrangement as

$$\mathbf{t}_\mathrm{T} = \begin{cases} \mathbf{t}_\mathrm{T}^\mathrm{test}, & \text{if } \Phi(\mathbf{t}_\mathrm{T}^\mathrm{test}) \leq 0 \\ -\mu_\mathrm{T} \lambda_\mathrm{N} \frac{\mathbf{t}_\mathrm{T}}{\|\mathbf{t}_\mathrm{T}\|}, & \text{else} \end{cases} \tag{3.6}$$

may also make sense if a variable, here $\mathbf{t}_\mathrm{T}$, has different definitions in two or more cases.

When several formulas are put together in an `align`-enviroment, each line gets its own equation number. However, in some cases it is preferred to have only one equation number. For that, a `split`-enviroment within the `align`-enviroment must be defined.

$$\begin{aligned} \delta W_\mathrm{PvV}^\mathrm{F} = & \underbrace{\int_{\Omega_0} \delta \mathbf{u} \cdot [\rho_0 \ddot{\mathbf{x}}] \, \mathrm{d}\Omega_0}_{\delta W_\mathrm{PvV}^\mathrm{kin}} + \underbrace{\int_{\Omega_0} \delta \mathbf{E} : \mathbf{S} \, \mathrm{d}\Omega_0}_{\delta W_\mathrm{PvV}^\mathrm{int}} \\ & \underbrace{- \int_{\Omega_0} \delta \mathbf{u} \cdot [\rho_0 \mathbf{b}] \, \mathrm{d}\Omega_0 - \int_{\Gamma_\mathrm{N}} \delta \mathbf{u} \cdot \hat{\mathbf{t}}_0 \, \mathrm{d}\Gamma_\mathrm{N}}_{-\delta W_\mathrm{PvV}^\mathrm{ext}} = 0. \end{aligned} \tag{3.7}$$

A formula in the `split`-enviroment can be aligned to only one `&` character. In case more information is to be added, the placing can be adjusted with the spacer `\quad`:

$$\begin{aligned} \lambda \in \mathcal{M}^- \qquad & \mathcal{M}^- = \Big\{ \lambda : \Gamma_\mathrm{C} \to \mathbb{R}^- \mid \lambda \in \mathbf{Q}'(\Gamma_\mathrm{C}), \lambda \leq 0 \Big\}, \\ \delta\lambda \in \mathcal{M}^+ \qquad & \mathcal{M}^+ = \Big\{ \delta\lambda : \Gamma_\mathrm{C} \to \mathbb{R}^+ \mid \delta\lambda \in \mathbf{Q}'(\Gamma_\mathrm{C}), \delta\lambda \geq 0 \Big\}. \end{aligned} \tag{3.8}$$

If the formula is further to be referenced, a `\label{Name}` is then assigned to it. Then, Formula (3.7) or Formula (3.8) can be referenced with `\eqref{Name}`. To automatically disable setting breaks between the word "Formula" and the equation number, a non-breaking space `~` can be used. This is very useful also when referring to pictures.

Furthermore:

- Formulas are to be incorporated into a sentence and are thus provided with a final punctuation mark, such as a comma or period.
- Each variable in formulas should be at least once explained. A variable and its name should be clearly identifiable.
- There should be no use of `eqnarray` or `array`-envirement, as incorrect spaces between symbols then arise.

3.4.2 Contents

There are certain rules how to write formulas. The main ones are summarized below. For a further study it is worth taking a look at the online documentations "amsmath" and "mathtools".

Scalars, Vectors, Matrices

Scalars are generally represented in italic style $y = mx + c$. The same case is for x-axis, x-direction or $\hat{u}_x$. Whereas vectors and matrices are written boldface and roman, e.g. normal vector $\mathbf{n}$ or the stiffness matrix $\mathbf{K}$. Also here, the use of abbreviations is useful, as $\mathbf{n}$ can be then generated with `\Bn` instead `\mathbf{n}`. Here the letter "B" stands for "bold". When a vector such as

$$\delta\mathbf{d} = \begin{bmatrix} \delta\mathbf{d}_1 \\ \delta\mathbf{d}_2 \\ \vdots \\ \delta\mathbf{d}_n \end{bmatrix} \tag{3.9}$$

is to be defined, a `bmatrix`-enviroment is used. In special cases where the entries are not centered, it is practical to use a `bmatrix*`-enviroment.

$$\mathbf{F} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} \qquad \text{is better than} \qquad \mathbf{F} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix} \qquad \text{or} \qquad \mathbf{F} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}. \tag{3.10}$$

Indices

In general, two different types of indexes are distinguished: italic and non-italic. Italic indexes are used when the letter is describing a variable, e.g. a summation over I.

$$\mathbf{u} \approx \mathbf{u}^h(\boldsymbol{\xi}) = \sum_{I=1}^{n} N_I(\boldsymbol{\xi}) \mathbf{d}_I \tag{3.11}$$

or in the update of acceleration

$$\ddot{\mathbf{u}}^{i+1} = \ddot{\mathbf{u}}^i + \Delta\ddot{\mathbf{u}}. \tag{3.12}$$

When the italic indice I or i are to be then referenced in the next sentence, I or i must be written italic again and not roman.

The non-italic indices are those, that represent a name, e.g. the index $(\bullet)_{\mathrm{N}}$ for the normal direction. As an abbreviation, `$\RN$` can be used instead of `$\textnormal{N}$` here. Here the letter "R" stands for "Roman". In the following formulas, "F" for Festkörper, "kin" for kinetic, "int" für internal and "ext" for external must be written as roman.

$$\begin{aligned} \delta W^h_{\mathrm{F}}(\mathbf{a}, \mathbf{d}) &= \delta W^h_{\mathrm{kin}} + \delta W^h_{\mathrm{int}} - \delta W^h_{\mathrm{ext}} \\ &= \delta \mathbf{d}^{\mathrm{T}} \mathbf{f}_{\mathrm{kin}}(\mathbf{a}) + \delta \mathbf{d}^{\mathrm{T}} \mathbf{f}_{\mathrm{int}}(\mathbf{d}) - \delta \mathbf{d}^{\mathrm{T}} \mathbf{f}_{\mathrm{ext}} = 0 \end{aligned} \tag{3.13}$$

At this point, one can argue about the discretization index $(\bullet)^h$, as it represents the discretization and thus stands for a name and could be written as roman. Historically, the letter h was introduced as the size of an element, reffering to a scalar variable which is then written as italic. Therefore, here in the institute, it is considered to write the index for the discretization $(\bullet)^h$ as italic.

Operators

Arithmetic operators like the natural logarithm "ln", the sine "sin" or "arg min", "grad" are never written as italic, because they represent a specific arithmetic operation. It wouldn't be the correct way to do if these operators are simply used with a `$\textnormal{}$`-command

to make them roman. Instead, if not already defined, a special `\operatorname{}`-enviroment must be used, as shown below.

$$\bar{\mathbf{x}}(\mathbf{x}^{\mathrm{s}}) = \underset{\mathbf{x}^{\mathrm{m}} \in \gamma_{\mathrm{C}}^{\mathrm{m}}}{\arg\min} \|\mathbf{x}^{\mathrm{s}} - \mathbf{x}^{\mathrm{m}}(\boldsymbol{\xi})\| \tag{3.14}$$

For many arithmetic operations the commands are already defined, e.g. `\Div` for Div or `\Grad` for Grad or `\dx` for $\mathrm{d}x$. These commands can be found in the file "Abkuerzungen.pdf" in chapter 0.4. Since the transpose is also representing an operator, in this case the rule for roman style applies here too. Nevertheless, the notation `\RT` for the indice T is sufficient.

The symbol of the scalar dot product "$\cdot$" is used frequently in many works. If scalar-valued variables are multiplied to each other, no product character "$\cdot$" is usually specified between the parameters, e.g. $y = mx + c$. The symbol "$\cdot$" is used for the scalar product of vectors instead, e.g. $\|\mathbf{x}\| = \sqrt{\mathbf{x} \cdot \mathbf{x}}$, or generally for single contraction, and the symbol ":" for double contraction.

Units

In sample calculations units must be specified. They shouldn't be written in italic style and have to have a half-space distance (`\,`), e. g. $E = 100\,\mathrm{kN/m^2}$ or $t = 0,1\,\mathrm{m}$. At this point it must be pointed out that the predefined unit commands have both the half-space distance and the correct font inclination.

In case axis labels of graphs are to be provided with a unit, there are two variants to do this: u_y in m or u_y/m.

3.5 Creating Charts

Tables are defined in a `table`-enviroment with embedded `tabular`-enviroment.The `tabular`-enviroment allows easy alignment of each column with the commands `c` for middle-aligned, `l` for left-aligned, `r` for right-aligned and `S` for an alignment on the decimal.

Tables such as Table 3.1 should be described and refferenced in the text.

3.6 Input of Pictures and Diagrams

You should save the pictures in the folder of their respective chapters. Every folder containing pictures has to be listed in the main document thesis.tex. Therefore you need the command `\graphicspath`. The path must be given relatively to the main document and you finish the command with a "/".

Mesh	Number of elements	Mesh size h [cm]	Strain energy Greville [J]	Error[%] Greville
1	1	12.5664	1.15122	23.1623
2	4	6.28319	1.36973	8.57804
3	16	3.14159	1.67895	12.0610
4	64	1.57080	1.48293	1.02218
5	256	0.78540	1.50929	0.73691
6	1024	0.39270	1.49694	0.08755
7	4096	0.19635	1.49839	0.00957
8	16384	0.09817	1.49825	-

Table 3.1: Number of elements, meshsize, distortion energy and relative error

1. type “figu” and press Crtl + space-bar

2. in the dialog window figure - choose Template for figure. The following dialog appears:

```
\begin{figure}[t]
  \begin{center}\small

  % Grafik: png, jpg, pdf
  \includegraphics[width=1.0\textwidth]{filename}
  % Inkscape Build
  \includesvg{filename}
  % Gnuplot mit tkiz
  \includegp{filename}

  \caption{figureCaption}
  \label{fig:figureLabel}
  \end{center}
\end{figure}
```

3. using a png, jpg, or PDF file, your need the first include-command and you can delete the others. If you use Inkscape svg files or Gnuplot gp files you need the second or third command, respectively. The command *filname* is the path given relatively from the the main document thesis.tex to the picture or gnuplot.

At this place the Inkscape file Figure 3.1 will be integrated. If you want to arrange the pictures side by side, e.g. they are cuttings from a video or something, you need to create a minipage for every picture.

Important: The pictures are always pasted in their original size. If the picture is too large you need to scale them with Inkscape. Changing a picture afterwards in LaTeXwill also change the fond size in the picture which is not wanted.

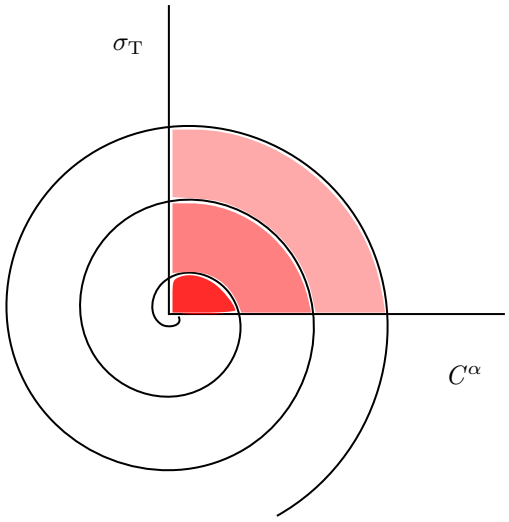


Figure 3.1: Inkscape Picture

3.7 Library Management

If you are using an external literature managing program like e.g. Zotero you can output an .bib file. You can then replace the file literatur.bib with the created bib-file. You can also manually change the literatur.bib by adding entries. Depending on the kind of literature you need to declare your source with @book, @phdthesis, @article, @incollection ....

```
@INCOLLECTION{ramm_vs_foerster_wall:2008,
  author = {Ramm, E. and  {von Scheven}, M. and  Förster, Ch. and  Wall, W.A.},
  title = {Interaction of incompressible flows and thin-walled structures},
  booktitle = {ECCOMAS Multidisciplinary Jubilee Symposium. New Computational
  Challenges in Materials, Structures and Fluids},
  publisher = {Computational Methods in Applied Sciences, 14, Springer-Verlag,
  Berlin, Heidelberg},
```

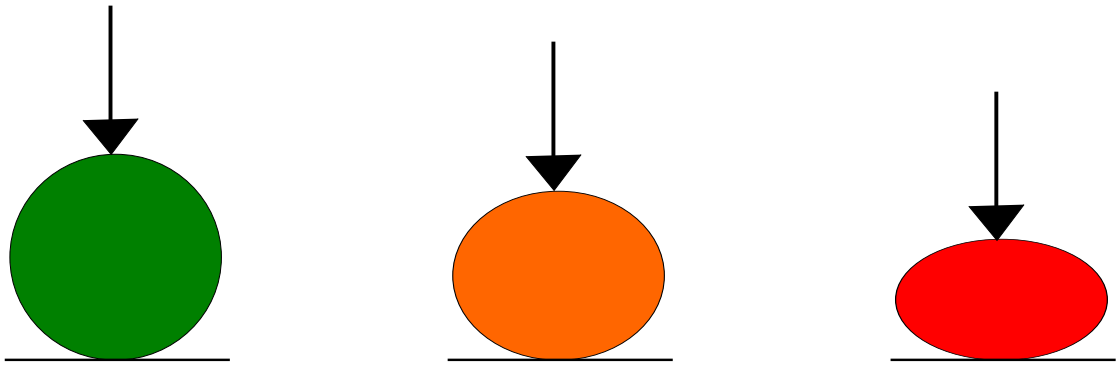


Figure 3.2: three pictures side by side

```
year = {2008},
pages = {219--233},
otherinfo = {}
```

In your bibligrophy only the sources are listed which has been quoted in your thesis. Depending on how you use the quote you need to use brackets or not. You don't need brackets if the source is directly used in the sentence (According to Bischoff (1999) a shell ...). Using a source in addition to your sentence demands the usage of brackets (The interaction between incompressible fluids and thin-walled structures should be considered(Ramm u. a. 2008)). Therefore we need two different literature commands: In the first case it is `\cite{bischoff:1999}` in the second it is `\citep{ramm_vs_foerster_wall:2008}`.

To update the references and the content you need to build your pdf-file twice.

4

Summary and outlook

Finally at this point you should write a summary of your work. Additionally it would be good to give a outlook how your thesis could be continued or completed and what might be improved.

Bibliography

Bischoff 1999
: Bischoff, M.: *Theorie und Numerik einer dreidimensionalen Schalenformulierung*, Bericht Nr. 30, Institut für Baustatik, Universität Stuttgart, Dissertation, 1999

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: Ramm, E. ; von Scheven, M. ; Förster, Ch. ; Wall, W.A.: Interaction of incompressible flows and thin-walled structures. In: *ECCOMAS Multidisciplinary Jubilee Symposium. New Computational Challenges in Materials, Structures and Fluids*. Computational Methods in Applied Sciences, 14, Springer-Verlag, Berlin, Heidelberg, 2008, S. 219–233